Expert Report Edward Friedman

Robert Peter Gale, MD, PhD, DSc(hc), FACP, FRCP, FRCPI (hon), MRSM

Remit I am asked by Mr. Christopher C. Taintor of Norman, Hansen & De Troy LLC to opine whether or not exposure to radiofrequency electromagnetic fields from a residential smart meter of the type proposed to be installed by Central Maine Power in the residence of Mr. Edward Friedman, to a reasonable degree of medical probability, worsen signs, symptoms and/or prognosis of Mr. Friedman's lymphoplasmacytic lymphoma/Waldenström macroglobulinemia. I am also asked to comment on the Declarations of plaintiff's experts Dr. David Carpenter and Mr. Kent Chamberlin and Deposition of Dr. David Carpenter.

Qualifications I received my AB degree with high honors in biology and chemistry from Hobart College in 1966 and my MD degree from the State University of New York at Buffalo in 1970. My postgraduate medical training (internal medicine, hematology and oncology) 1970-1973 was at the University of California, Los Angeles (UCLA) from 1972-1976. In 1976 I received a PhD in microbiology and immunology from UCLA following doctoral work focusing on cancer immunology. My studies at UCLA were funded by the U.S. National Institutes of Health (NIH) and the Leukemia Society of America where I was the Bogart Fellow and Scholar. From 1973-1983, I was on the faculty of the UCLA School of Medicine in the Department of Medicine, Division of Hematology & Oncology from 1972-1993.. I have published over 1300 scientific articles and more than 20 books, mostly on hematology, leukemia (biology and treatment), transplantation (biology, immunology and treatment), cancer biology and immunology and radiation biology. I have written on medical topics, nuclear energy, weapons and terrorism and politics of US-Soviet relations in articles for The New York Times, Los Angeles Times, Washington Post, USA Today and Wall Street Journal.

From 1980-1997, I was Chairman of the Scientific Advisory Committee of the International Bone Marrow Transplant Registry (IBMTR), an organization of more

than 400 transplant centers in over 60 countries working together to analyze and advance knowledge about blood cell and bone marrow transplants. Since 1989, I was a member of the Scientific Advisory Board of the Autologous Blood and Marrow Transplant Registry (ABMTR). In 1989-2003 I chaired the Scientific Advisory Board of the Center for Advanced Studies in Leukemia. From 1986-1993, I was president of the Armand Hammer Center for Advanced Studies in Nuclear Energy and Health, a foundation supporting research on medical aspects of nuclear issues. From 1993-1999, I was Senior Physician and Corporate Director at Salick Health Care (SHC), Inc. in Los Angeles (now Aptium Oncology), a subsidiary of AstraZeneca Corp. From 2000-2004 I was Senior Vice-President for Medical Affairs at Antigenics, Inc. I was also a Senior Medical Consultant to Oxford Health Plans in areas of advanced medical technologies. From 2004 to 2007, I was Senior Vice-President of Research for ZIOPHARM Oncology, Inc. In 2007, I joined Celgene Corp., where I was Executive Director of Clinical Research, Hematology and Oncology. Celgene Corp. was acquired by Bristol-Myers Squibb Corp and I was employed there until 1 January, 2020. I am currently a consultant to several biotechnology companies with a focus on cancer.

At the Weizmann Institute of Science, my colleagues and I identified the molecular basis of chronic myelogenous leukemia (CML). Whilst at the Rockefeller University, I helped unraveled genetic aspects of leukaemia-risk in Fanconi anemia.

I have contributed substantially to basic science and clinical research in how cancers, especially leukemias, develop. Increasingly, I have focused on issues of clinical trials design, implementation and analyses and in the use of observational databases, expert consensus and clinical practice guidelines to determine safe and effective cancer therapies. I have been able to translate my knowledge and expertise in the molecular biology of blood cancers to other cancers.

I am Visiting Professor of Haematology, Centre for Haematology Research, Department of Immunology and Inflammation, Imperial College London, UK. I have been a visiting professor, scholar or lecturer at many universities including Weizmann Institute of

Science (Meyerhoff Visiting Scientist 1983-84), Academy of Medical Sciences-USSR, All-Union Cancer Center-USSR, Universities of Cape Town, Bologna, Michigan and Rome, Cornell Univ., Tokyo Univ., Tufts Univ., Uppsala Univ., Roswell Park Cancer Center, Cleveland Clinic, Swedish National Radiation Protection Board, UK Royal College of Physicians and The UK Royal Society of Pathology.

I am a Fellow of the American College of Physicians, the Royal College of Physicians, The Royal College of Physicians of Ireland (hon) and a Member of the Royal Society of Medicine. I am an honorary member of the Russian Academy of Science, Chinese Academy of Medical Science and a Diplomat of the American Boards of Internal Medicine and Oncology and eligible in the American Board of Hematology.

I am a member of several learned societies including The American Association for the Advancement of Science, American Association of Immunologists and American Federation for Cancer Research, American Federation for Clinical Research, American Society for Clinical Oncology, American Society of Hematology, International Society of Hematology, International Society of Experimental Hematology and others.

I am Editor-in-Chief of *Leukemia*, Executive Editor of *Bone Marrow Transplantation*, Associate Editor of *Clinical Transplantation* and on the editorial boards of scientific journals including *Acta Haematologica, Advances in Cell and Gene Therapy, Blood Reviews, Case Reports in Medicine, Cell Transplantation, HemOnc Today* (Section Editor), *Leukemia Research, Leukemia Research Reports, Transplantation* and others and review typescripts for the *New England Journal of Medicine, Lancet, Annals of Internal Medicine, JAMA, Journal of Clinical Oncology* and others.

I received many awards for my scientific achievements and contributions including the President's Award, New York Academy of Science, Scientist of Distinction Award Weizmann Institute of Science, Distinguished Alumni Award from Hobart College and Intra-Science Research Foundation Award. I hold honorary degrees including DSc from Albany Medical College and the University of Buffalo, LHD from Hobart College and DPS from MacMurray College.

I am widely recognized for my humanitarian activities. In 1986, I was asked by the government of the Soviet Union to coordinate medical efforts for victims of the Chernobyl nuclear power station accident. In 1987, I was asked by the government of Brazil to coordinate medical efforts for victims of a radiation accident in Goiania. In 1988, I was part of the US medical emergency team sent in the aftermath of an earthquake in Armenia. In 1999 I was asked by the government of Japan to treat victims of the nuclear criticality accident near Tokyo. In 2011, I was called to Japan to deal with medical consequences of the Fukushima nuclear power station accident have also been a neutral war observer for the governments of Croatia and Armenia and a medical consultant to the government of Tartarstan. I have received several awards for my humanitarian activities including the Olender Peace Prize, City of Los Angeles Humanitarian Award, Myasthenia Gravis Foundation Humanitarian Award and an Honorary Medals from the Russian and the Ukraine Academies of Medical Sciences. My public service includes giving expert testimony to several US Congressional Committees on health policy issues, consultation for US Public Health Service, Office of Technology Assessment (OTA), Agency for Health Care Policy and Research AHPCR), the Task Force on Neurosciences of the US Office of Technology Assessment, California Senate Task Force on Emergency Medical Response for Nuclear Accidents. In addition to my academic publications, I have written popular books on Chernobyl, US nuclear energy policy and radiation. Copies of my *curriculum vitae* and list of more than 1200 publications are attached.

Opinion

Based on data I reviewed and considered I opine, to a reasonable degree of medical probability, it is less likely than not exposure to radiofrequency electromagnetic fields from a smart meter of the type proposed to be installed by Central Maine Power in the residence of Mr. Edward Friedman, would worsen signs, symptoms and/or prognosis of Mr. Friedman's lymphoplasmacytic lymphoma/Waldenström macroglobulinemia.

Put otherwise, after an extensive review of the biomedical literature and reports from scientific bodies, medical authorities and regulatory agencies I found no credible evidence exposure to radiofrequency magnetic fields such as those emitted from a smart meter of the type proposed to be installed by Central Maine Power at the residence of Mr. Edward Friedman would worse signs, symptoms or prognosis in someone with lymphoplasmacytic lymphoma/Waldenström macroglobulinemia including Mr. Friedman.

Method

The method I used to address the question of whether, to a reasonable degree of medical probability, *the weight-of-evidence* indicates exposure to radiofrequency electromagnetic fields from a smart meter of the type proposed to be installed in the residence of Mr. Edward Friedman, is likely to worsen signs, symptoms or prognosis of Mr. Friedman's cancer follows methods and guidelines from several sources including, but not limited to, the: (1) Reference Manual on Scientific Evidence (2nd Ed.; Federal Judicial Center; 2000; (2) Guidelines for Cancer Risk Assessment (US Environmental Protection Agency; 2005); (3) Risk Assessment in the Federal Government: Managing the Process (National Research Council; National Academy of Science; 1983); (4) Science and Judgment in Risk Assessment (National Research Council; National Academy of Science; 1994); (5) 15th Report on Carcinogens (National Toxicology Program [NTP]; 2016; US Department of Health and Human Services; 2014); (6) International Agency for Research in Cancer (IARC) of the World Health Organization (WHO) and United Nations (UN). (7) Monograph 75s on the Evaluation of Carcinogenic Risks to Humans, Supplement 7, Overall Evaluations of Carcinogenicity 1987).

This *weight-of-evidence* methodology is built on to the *Hill viewpoints* but adds elements which increase scientific validity and is summarized in the US EPA Guidelines for Carcinogen Risk Assessment (2005. P. 1-11):

The cancer guidelines emphasize the importance of weighing all of the evidence in

reaching conclusions about the human carcinogenic potential of agents. This is accomplished in a single integrative step after assessing all of the individual lines of evidence… Evidence considered includes tumor findings, or lack thereof, in humans and laboratory animals; an agent's chemical and physical properties; its structure-activity relationships (SARs) as compared with other carcinogenic agents; and studies addressing potential carcinogenic processes and mode(s) of action, either in vivo or in vitro.

This approach is also echoed in the NTP guidelines for carcinogen risk assessment:

Conclusions regarding carcinogenicity in humans or experimental animals are based on scientific judgment, with consideration given to all relevant information. Relevant information includes, but is not limited to, dose response, route of exposure, chemical structure, metabolism, pharmacokinetics, sensitive sub-populations, genetic effects, or other data relating to mechanism of action or factors that may be unique to a given substance.

Briefly, a *weight-of-evidence* analysis is a structured synthesis of lines of evidence, possibly of varying quality, to determine the degree of support for hypotheses. There a several stages to a weight-of-evidence analysis: (1) determining the appropriate focus, based on the objectives and preliminary consideration of available data, formulating the question(s) to be assessed and developing a protocol; (2) establishing lines of evidence including identifying and selecting studies, assessing the quality of the studies and analyzing a set of studies of similar type; (3) integrating data from available lines of evidence to determine the degree of support for hypotheses or to estimate quantities of interest; and (4) an explicit presentation of the weight-of-evidence in a form that maximally supports a scientific and/or medical conclusion.

It follows that to reach an unbiased scientific opinion it is necessary to review publications and data in the scientific and biomedical literature. Typically this is done by performing searches for publications on relevant topics such as effects of smart meters or devices emitting similar radiofrequency magnetic waves on signs, symptoms and/or prognosis of cancer, especially in persons with cancers like this of

plaintiff. Often this is done using the PUBMED search engine of the US National Library of Medicine and Google Scholar.

In forming my opinion I considered the following concepts, issues and data: (1) molecular events underlying cancer progression; (2) biological relationship between an exposure and cancer progression; (3) effect(s) of such exposures on animal and human cells; (4) association between such exposures and cancer progression in animals and, when available, humans; and (5) mechanism(s) of action of radiofrequency electromagnetic fields.

I used several strategies to review publications and data in scientific and medical literature in forming my opinion. I performed searches for scientific and biomedical publications using the PUBMED search engine of the US National Library of Medicine and Google Scholar. I sought publications representing a range of opinions including those supporting and contrary to my opinion as stated in this report. I read and/or re-read all or parts of several relevant textbooks covering diverse disciplines including medicine, cell biology, cancer biology, carcinogenesis, epidemiology and physics. I also reviewed medical records of Mr. Edward Friedman provided by Mr. Taintor.

Estimated Exposure from a Residential Smart Meter to Plaintiff

Medical History

Mr. Edward Friedman is a 67 year old male with lymphoplasmacytic lymphoma/Waldenström macroglobulinemia. When In 2001 he learned his mother had an immunoglobulin M (IgM) monoclonal gammopathy he asked his physician to test him for a similar abnormality. A workup showed a IgM monoclonal gammopathy with a IgM-kappa of 835 mg/dL. No therapy was given and his IgM concentrations were followed. His IgM concentration in 2003 was 915 mg/dL and in 2010, 1210 mg/dL. In 2013 he was noted to have severe anaemia with an IgM concentration of 2585 mg/dL. A bone marrow biopsy show abnormalities consistent with lymphoplasmacytic lymphoma/Waldenström macroglobulinemia. His initial therapy was with with

bendamustine and rituximab to which he responded. In 2016 there was disease progression and he was begun on ibrutinib to which he again responded. The most recent IgM concentration available to me was 295 mg/dL in April, 2021. At this time his physician wrote to the US Federal Aviation Administration commenting: *there are no restrictions placed on further activity*.

Mr. Friedman has a history of cold urticaria as a child, a condition sometimes associated with lymphoplasmacytic lymphoma/Waldenström macroglobulinemia. Also, because his mother has an IgM monoclonal gammopathy there is a substantial likelihood Mr. Friedman has had an abnormality of IgM-producing B-lymphocytes since birth and which has progressed over his lifetime eventuating in lymphoplasmacytic lymphoma/Waldenström macroglobulinemia. Indicate Mr. Friedman is participating in a study of familial Waldenström macroglobulinemia at the US National Institutes of Health, Division of Cancer Epidemiology and Genetics, Genetic Epidemiology Branch to which he has provided medical data and blood samples. There is also said to be a family history of chronic lymphocytic leukaemia (CLL), a cancer closely related to lymphoplasmacytic lymphoma/Waldenström macroglobulinemia. These data indicate it is highly likely Mr. Friedman has an inherited form of lymphoplasmacytic lymphoma/Waldenström macroglobulinemia present at birth and slowly progressive. About 20 percent of people with lymphoplasmacytic lymphoma/Waldenström macroglobulinemia have a family member with this or a related B-lymphocytic abnormality including a related cancer. Most people with lymphoplasmacytic lymphoma/Waldenström macroglobulinemia have a mutation in the *MYD88* gene. Other genetic abnormalities include mutation in the *CXCR4* gene, deletions of chromosomes 6q and 13q14 and trisomy of chromosome 4. These were likely tested for at the NIH but there is no relevant report in the medical records I reviewed.

Mr. Friedman has several other medical conditions including benign prostatic hypertrophy, hypertension, osteoporosis and arterio-sclerotic cardio-vascular disease. He has surgical resection of a meningioma in 1995 and knee surgeries in 1990 and 1993. The only drugs indicated in the medical records available to me are ibrutinib and rosuvastatin but it is likely there are others. He is not a smoker and has only modest

alcohol exposure.

Lymphoplasmacytic lymphoma/Waldenström macroglobulinemia is more common in males and persons of European descent and risk increases with age. Mr. Friedman does not have hepatitis C nor any autoimmune disorder associated with lymphoplasmacytic lymphoma/Waldenström macroglobulinemia.

Approach

The approach I followed was 1st determine general causation, namely whether to a reasonable degree of medical probability the *weight-of-evidence* indicates exposure to radiofrequency electromagnetic fields from a residential smart meter of the type proposed to be installed by Central Maine Power at the residence of Mr. Edward Friedman is more likely than not to worsen sign, symptoms and/or progression of cancer in laboratory models, animal models and/or humans. Were I to conclude so my strategy was to next consider specific causation, namely, whether, to a reasonable degree of medical probability the *weight-of-evidence* indicates exposure to radiofrequency electromagnetic fields from a residential smart meter of the type proposed to be installed by Central Maine Power at the residence of Mr. Edward Friedman is more likely than not to worsen signs, symptoms and/or progression of lymphoplasmacytic lymphoma/Waldenström macroglobulinemia in Mr. Friedman.

It is important to emphasize the issue I considered is whether exposure to radiofrequency electromagnetic fields such as those emitted from a smart meter of the type proposed to be installed by Central Maine Power in the residence of Mr. Edward Friedman is more likely than not to worsen sign, symptoms and/or progression of cancer in laboratory models, animal models and/or humans, NOT whether such exposures cause cancer and/or *promote* cancer development in laboratory models, animal models or humans. (*Promotion* has a precise scientific meaning in the context of cancer development which differs from other non-scientific use of the term *promotion*.)

In performing my research and reaching my opinions I considered a wide range of data derived from diverse sources such as reports from scientific bodies, regulatory agencies, heath authorities, textbooks and citations identified by searches in PUBMED of the National Library of Medicine, Google Scholar and others. I also reviewed publications cited in critical reviews such as IARC monographs and EPA documents. In forming my opinion I considered data and citations supporting and not supporting my *weight-of-evidence* approach discussed herein. As such, my analyses was comprehensive and unbiased.

General causation

The issue I considered is whether, to a reasonable degree of medical probability, the *weight-of-evidence* indicates exposure to radiofrequency electromagnetic fields such as those emitted from a smart meter proposed to be installed by Central Maine Power at the residence of Mr. Edward Friedman is, more likely than not, to worsen sign, symptoms or prognosis of cancer in laboratory models, animal models and/or humans.

To explore this issue I interrogated PUBMED of the US National Library of Medicine for English-language citations 1966 to January, 2022 using the Boolean search terms *radiofrequency* AND/OR *electromagnetic field* AND *cancer* AND *progression* NOT *causation* NOT promotion. I retrieved 49 citations which met these criteria (**Appendix 1**). My review of abstracts of these citations identified 10 potentially relevant to whether exposure to radiofrequency electromagnetic fields is, more likely than not, to worsen sign, symptoms or prognosis of cancer in laboratory models, animal models and/or humans (Appendix 2). Next, I reviewed each publication assigning a qualitative score to the *quality of evidence* from weak to moderate to strong.

References 1 and 3 deal with exposure of human cells in the laboratory to radiofrequency electromagnetic fields. Both report **increased** killing of cancer cells

simultaneously treated with an anti-cancer drug (temozolomide) and radiofrequency electromagnetic fields consistent with an anti-cancer benefit rather than a detriment. Reference 2 reports no adverse effects of exposure to radiofrequency electromagnetic fields in persons with brain cancer. Reference 4 deals with effects on a surrogate endpoint (natural-killer cells) of unknown biological importance in **occupationally exposed** workers. Reference 5 is a laboratory study of brain cancer cells of unknown relevance to cancer prognosis. Reference 6 is a laboratory experiment using a human cancer cell line but where the cells were simultaneously exposed to high doses of ionizing radiations. The authours conclude: *We concede, however, that we have not demonstrated that ELF increases the incidence of cellular transformation*. Reference 7 looks at the effect of electromagnetic fields in rats injected with leukaemia cells and is perhaps most relevant to the issue in this litigation. The authours conclude: … ***there were no overall effects of magnetic fields on splenomegaly or survival in exposed animals***. *In addition, no significant and/or consistent differences were detected in hematological parameters between the magnetic field exposed and the ambient control groups*. (Bolding mine.) Reference 8 is a review focused on cancer causation which does not indicate exposure to radiofrequency electromagnetic radiations of the type emitted from a smart meter worsen signs, symptoms or prognosis of cancer. Reference 9 is another study of injecting mice with leukaemia cells and exposing them to magnetic fields. The authours conclude: *No statistically significant differences … in survival, spleen weight, or body weight resulted between P388-treated or nontreated mice from exposure to the magnetic field.* ***No effect on the incidence or progression of P388 leukemia was apparent***. (Bolding mine.) This reference is also that most relevant to this litigation. Reference 10 is a review which make no comment on adverse effects of radiofrequency electromagnetic fields on cancer progression.

Most studies I reviewed were of weak or moderate quality. The 3 most relevant studies to the issue in this litigation are references 2, 7 and 9 which look at survival of humans, rats and mice with a brain cancer (reference 2) or leukaemia (references 7 and 9). None of these studies report worsening of signs, symptoms or progressions of cancer in experimental animals or persons exposed to radiofrequency electromagnetic fields like those emitted from a smart meter.

I also reviewed 2 publications cited by plaintiff's expert witness Dr. David Carpenter which he claims prove exposure to radiofrequency electromagnetic fields such as those emitted by a smart meter will worsen signs, symptoms and/or prognosis of plaintiff's cancer and which did not appear in my PUBMED search: (1) Foliart DE, Pollock BH, Mezei G et al.. 2006. Magnetic field exposure and long-term survival among children with leukaemia. Br J Cancer 94:161-4; and (2) Svendsen AL, Weihkoph T, Kaaatsch P *et al.* 2007. Exposure to magnetic fields and survival after diagnosis of childhood leukemia: A German cohort study. Cancer Epidemiol Biomark Prev 16:1167-71.

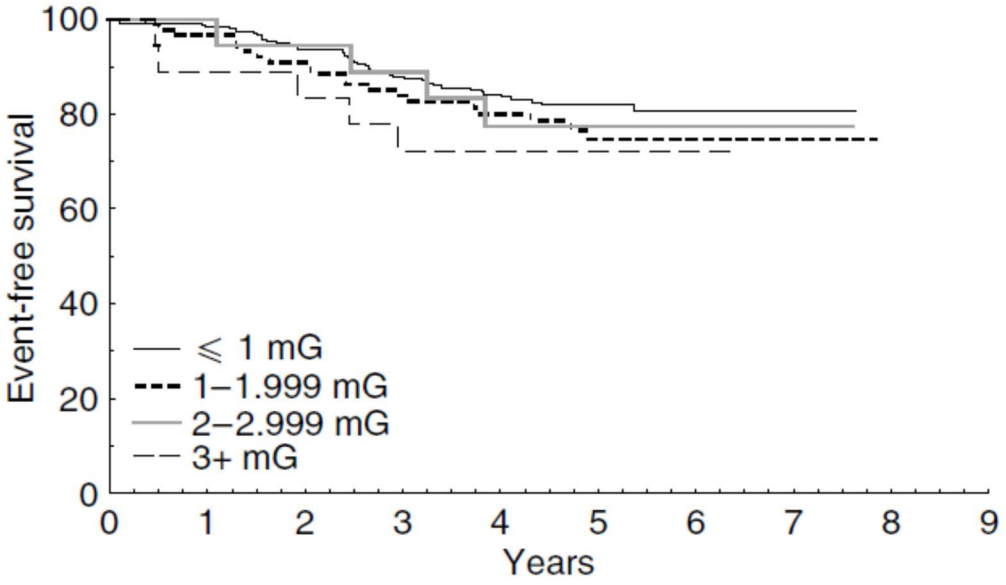
Both studies are in children with acute lymphoblastic leukaemia, not lymphoplasmacytic lymphoma/Waldenström macroglobulinemia, entirely different diseases. Acute lymphoblastic leukaemia is a type of leukaemia common in children whereas lymphoplasmacytic lymphoma/Waldenström macroglobulinemia is a type of lymphoma common in adults with different codes in the International Classification of Diseases (ICD). Acute lymphoblastic leukaemia in the study cited occurs in children whereas lymphoplasmacytic lymphoma/Waldenström macroglobulinemia occurs predominately in adults. Therapy of these cancers is entirely different as is their prognoses.

The study by Foliart *et al*. is flawed for several reasons. First, it was funded by Electric Power Research Institute (EPRI) and Electricite' de France. Both organizations have potential vested interests in the study outcome. Second, there is no indication of potential conflict(s) of interest of the authours. This is considered mandatory in scientific articles. Third, there is no indication the data are available to other scientists to test reproducibility of the authours' conclusions. This is considered mandatory in most scientific journals. Fourth, interviews for exposure and data collection where done by the Public Health Institute whose source(s) of funding is not disclosed in the article. Fifth, there are substantial and important subject selection biases. For example, only 29 percent of potential study subjects agreed to participate, 5 percent never returned the meter designed to quantity magnetic field exposure and data from only 79 percent of potential subjects were analyzed. These selection biases make the study conclusions unreliable. These limitations are mentioned by the authours in the

Discussion section of the article They state: *Three limitations of our study are noteworthy. … only 5% of the cohort (19 children) had a TWA* (time weighted average) *above 0.3 mT. Thus, we had limited ability to evaluate outcome among children exposed to more than 0.3 mT and could perform no meaningful analyses above 0.4 mT. Secondly, less than one-third of potentially eligible children enrolled into our study…. Finally, our survival analyses were based on first-year MF exposure assessments. However, a single measurement was less useful among children who changed residences. Twelve percent of children with first-year measurements moved during the exposure assessment protocol. The total number of children who changed residences during the entire course of follow-up is unknown.* ***The single assessment of MF exposure in residentially mobile children may not be an adequate surrogate of MF exposure over the study's extended follow-up period***. (Bolding mine.) In my *weight-of-evidence* analysis I rated the quality of this study weak.

Importantly, the authours state: ***No consistent or statistically significant trend was noted between increasing exposure to MF [***magnet field] ***and event-free survival or risk of death****. Although we report poorer survival among children with the highest MF exposure category,* ***clinical inferences are limited, with results possibly attributable to chance alone****. Independent confirmation is needed, as our study is the first to look at relapse and survival and thus* ***our findings can be viewed only as hypothesis generating***. (Bolding mine.)

The figure below from the article by Foliart *et al*. shows no significant difference in event-free survival of children with acute lymphoblastic leukaemia exposed to different strengths of magnetic fields.



The second study cited by Dr. Carpenter as supporting his opinion is Svendsen *et al*. 2007 (Svendsen AL, Weihkoph T, Kaaatsch *et al*. 2007. Exposure to magnetic fields and survival after diagnosis of childhood leukemia: A German cohort study. Cancer Epidemiol Biomark Prev 16:1167-1171) The authours also studied children with acute lymphoblastic leukaemia rather than adults with lymphoplasmacytic lymphoma/Waldenström macroglobulinemia. The endpoint Svendsen *et al*. studied was survival not event-free survival differing importantly from the endpoint in the study by Foliart *et al.* Also, Svendsen *et al*. measured 24 hour magnetic field exposure in contrast to Foliart *et al.* who studied a time weighted average. The follow-up interval of the studies also differed, 5 *versus* almost 10 years.

When Svendsen *et al.* tried to replicate the event-free survival reported by Foliart *et al*. they reported Hazard Ratios which were not statistically significant. These data indicate conclusions of the Foliart *et al.* study are not supported by results of the study of Svendsen *et al*. Table 3 of the study by Svendsen *et al.*. indicates a non-significant increase in deaths in children in the highest magnetic field exposure cohort. Moreover, Foliart *et al*. reported worse event-free survival only in children exposed to magnetic fields greater than 0.3 μT which was not found in the study by Svendsen *et al*. The article by Svendsen *et al*. does not indicate funding source, potential conflicts of interest nor data availability. These elements are considered essential requirements in scientific

articles. The authours of the study by Svendsen *et al*. conclude: ***In all, the evidence is still based on small numbers, and a biological mechanism to explain the findings is not known***. (Bolding mine.) Reproducibility is a key element of scientific research. Results which are not replicable or reproducible should be down-graded. In my *weight-of-evidence* analysis I rated the quality of this study weak.

There have been several larger studies of event-free survival and survival in children with acute lymphoblastic leukaemia after the publications by Foliart *et al*. and Svendsen *et al*. These studies are much larger and of higher quality. For example, Schuz *et al*. 2012 studied the relationship between exposure to extremely low frequency magnetic fields (ELF-MF) in more than 3,000 children from 6 countries (Schüz J, Grell K, Kinsey S. 2012. Extremely low-frequency magnetic fields and survival from childhood acute lymphoblastic leukemia: An international follow-up study. Blood Cancer J. 21;2(12):e98. doi: 10.1038/bcj.2012.43. PMID: 23262804; PMCID: PMC3542478). These authours reported no impact on event-free survival or survival in children exposed to extremely low frequency magnetic fields in the ranges studied by Foliart *et al*. and Svendsen *et al*. The authours concluded: ***ELF–MF exposure has no impact on the survival probability or risk of relapse in children with ALL***. (Bolding mine.)

Lastly, I reviewed but did not rely on reports from scientific bodies, medical authorities and regulatory agencies not indexed in PUBMED. For example, IARC Monograph 102; Non-Ionizing Radiation, Part 2: Radiofrequency Electromagnetic Fields. 2013. Sections 2.2 (pages 158-187) reviews data on cancer in humans from environmental exposure from fixed-site transmitters. There is extensive discussion of radiofrequency electromagnetic fields and cancer causation with > 200 references but no data indicating exposure to radiofrequency electromagnetic fields worsens signs, symptoms and/or progression of cancer in humans. Although the IARC Committee concluded there is *limited evidence* for carcinogenicity of radiofrequency radiation there is no conclusion exposure to radiofrequency electromagnetic fields worsened signs, symptoms and/or progression of cancer in animals or humans. Moreover, the IARC designation of RFR [radiofrequency radiation] as a group 2B agent (a *possible* carcinogen) is frequently misunderstood. The most recent IARC communication states:

… ***despite considerable research efforts, no mechanism relevant for carcinogenesis has been consistently identified to date***. (Bolding mine.) Importantly, cancer causation is not at issue in this litigation.

Another reference I reviewed but did not rely on is the WHO IARC World Cancer Report (2020; Section 2.5 pages 84-91) whose authours state: ***Most of the epidemiological research does not support an association between mobile phone use and tumours occurring in the head, which is the body part with the highest exposure to radiofrequency electromagnetic fields***. And: ***Despite considerable research efforts, no mechanism relevant for carcinogenesis of radiofrequency electromagnetic fields has been consistently identified to date***. *Also,* ***most of the epidemiological research does not indicate carcinogenicity of radiofrequency electromagnetic fields***. (Bolding mine.)

I also reviewed but did not rely on the US FDA Review of Published Literature between 2008 and 2018 of Relevance to Radiofrequency Radiation and Cancer (2020) which considered 125 articles relevant to effects of RFR [radiofrequency radiations] on animals. The authours concluded: … ***none of these [studies} have adequately demonstrated that localized exposure to RFR at any level … can lead to adverse effects***. The authours also discuss 70 relevant epidemiological studies published as peer-reviewed scientific evidence. They conclude: ***Based on the studies that are described in detail in this report, there is insufficient evidence to support a causal association between RFR exposure and tumorigenesis. There is a lack of clear dose response relationship, a lack of consistent findings or specificity, and a lack of biological mechanistic plausibility***. (Bolding mine.) Again, comments regarding cancer causation are not the issue in this litigation.

I also reviewed but did not rely on a report from the National Institute of Environmental Health and Safety (NIEHS) of the US National Institutes of Health (1992). After reviewing available data the expert panel concluded: ***It is our opinion that based on evidence to date, ELF-EMF exposure would not be listed in the "Report on Carcinogens" as an agent "reasonably anticipated to be a human carcinogen."***

This is based on the limited epidemiological evidence and the findings from the EMF-RAPID Program that did not indicate an effect of ELF-EMF exposure in experimental animals or a mechanistic basis for carcinogenicity. (Bolding mine.)

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Based on my *weight-of-evidence* review of these data I opine to a reasonable degree of medical certainty exposure to radiofrequency electromagnetic fields like those emitted from a smart meter is less likely than not to worsen signs, symptoms and/or progression of cancer in laboratory models, animal models or humans.

Specific Causation

Having determined to a reasonable degree of medical certainty exposure to radiofrequency electromagnetic fields is less likely than not to worsen signs, symptoms and/or prognosis of cancer in laboratory models, animal models or humans there was no need to consider whether the *weight-of-evidence* supports the notion exposure to radiofrequency electromagnetic fields are less likely than not to worsen signs, symptoms and/or prognosis of lymphoplasmacytic lymphoma/Waldenström macroglobulinemia. However, for completeness I repeated my PUBMED searches adding the search term *lymphoplasmacytic lymphoma/Waldenström macroglobulinemia.* No citations were identified. I also repeated my PUBMED search using the search terms *radiofrequency* AND/OR *electromagnetic field* AND *lymphoplasmacytic lymphoma/Waldenström macroglobulinemia.* The search identified 1 additional citation: Huss *et al*. 2018 (Huss A, Spoerri A, Egger M *et al*. 2018. Occupational extremely low frequency magnetic fields (ELF-MF) exposure and hematolymphopoietic cancers - Swiss National Cohort analysis and updated meta-analysis. Environ Res. 164:467-74). This study was in persons **occupationally** exposed rather than exposed from a residential smart meter. It included persons with Waldenström macroglobulinemia. The authours concluded: ***Our analysis provided no convincing evidence for an increased risk of death from a range of hematolymphopoietic cancers in workers exposed to high or medium levels of ELF magnetic fields***. (Bolding

mine.) Moreover, because the study considered risk of death it is not relevant to the issue of worsening of signs, symptoms and/or prognosis of someone with lymphoplasmacytic lymphoma/Waldenström macroglobulinemia. I rated this study high quality but not relevant to the issue or exposure to radiofrequency electromagnetic fields worsening signs, symptoms and/or prognosis of someone with lymphoplasmacytic lymphoma/Waldenström macroglobulinemia.

A second cross-referenced study (Koeman T, van den Brandt PA, Slottje P *et al*. 2014). Occupational extremely low-frequency magnetic field exposure and selected cancer outcomes in a prospective Dutch cohort. Cancer Causes Control. 25: 203-14) dealt with cancer causation and in **occupationally** exposed persons. I rated this study high quality but not relevant to the issue of exposure to radiofrequency electromagnetic radiations such as those emitted from a smart meter worsening signs, symptoms and/or prognosis of someone with lymphoplasmacytic lymphoma/Waldenström macroglobulinemia.

In summary, in my extensive review of the biomedical literature and reports from scientific bodies and regulatory agencies I found no credible evidence exposure to radiofrequency magnetic field such as those emitted from a smart meter of the type proposed to be installed by Central Maine Power at the residence of Mr. Edward Friedman would worsen signs, symptoms or prognosis in someone with lymphoplasmacytic lymphoma/Waldenström macroglobulinemia like Mr. Friedman.

Rebuttal to Testimony of Dr. David Carpenter

1. There are several important errors and limitations which compromise the testimony of Dr. Carpenter which I detail below.

2. After attending medical school Dr. Carpenter has no further medical training or practice. He has not diagnosed nor cared for anyone with a medical illness. He has not diagnosed nor treated anyone with plaintiff's cancer (Waldenström macroglobulinemia). He has no medical basis on which to predict the course of plaintiff's cancer to have an informed

opinion on what exposures might or might not affect plaintiff's cancer including whether exposure to radiofrequency electromagnet fields including those emitted from a smart meter could affect plaintiff's signs or symptom or prognosis.

3. Dr. Carpenter does not describe the method he used to reach his opinions. He does not indicate he followed recommendations for judging scientific evidence from any scientific body or regulatory agency such as: (1) Reference Manual on Scientific Evidence; (2) US Environmental Protection Agency; (3) US National Research Council; (4) US National Academy of Science; (5) US National Toxicology Program [NTP]; (7) US Department of Health and Human Services [US DHHS]; (8) International Agency for Research in Cancer (IARC); (9) World Health Organization (WHO) and others.

4. There is no indication Dr. Carpenter used a *weight-of-evidence* methodology or any other established and reproducible methodology to evaluate risk from exposure to radiofrequency electro-magnetic fields as recommended by these scientific organizations and regulatory agencies and which is considered best practice in evaluating a scientific or medical question. A *weight-of-evidence* methodology approach is built on to the Hill *viewpoints* but adds elements which increase scientific validity.

5. I discuss the *weight-of-evidence* approach to answering scientific questions in detail above. Briefly put, a weight-of-evidence analysis is a structured synthesis of lines of evidence, possibly of varying quality, to determine the degree of support for hypotheses.

6. There a several stages to a weight-of-evidence analysis: (1) Determining the appropriate focus, based on the objectives and preliminary consideration of available data, formulating the question(s) to be assessed and developing a protocol; (2) Establishing lines of evidence including identifying and selecting studies, assessing the quality of the studies and analyzing a set of studies of similar type; (3) Integrating data from available lines of evidence to determine the degree of support for hypotheses or to estimate quantities of interest; and (4) An explicit presentation of the weight-of-evidence in a form that maximally supports a scientific and/or medical conclusion.

7. It follows that to reach an unbiased scientific opinion it is necessary to review publications and data in the scientific and medical literature. Typically this is done by performing searches for scientific and biomedical publications on relevant topics such as effects of smart meters or similar radiofrequency waves on prognosis and signs and symptoms of cancer, especially in persons with cancers like this of plaintiff. Typically this is done using the PUBMED search engine of the US National Library of Medicine and Google Scholar.

8. In forming a scientific or medical opinion it is necessary to consider publications representing a range of opinions including those supporting and contrary to an experts opinion as stated in this report. There is no indication this was done by Dr. Carpenter who cites only references supporting his opinion ignoring a large body of scientific and medical publications with conclusions contrary to his.

9. For example, Dr. Carpenter cites a report from the International Agency for Cancer Research (IARC), a WHO agency dealing with cancer causation which is not at issue in this litigation but fails to cite or consider a recent report from the WHO stating: *To date, no adverse health effects from low level, long-term exposure to radiofrequency or power frequency fields have been confirmed*.

10. And: Experiments with healthy volunteers indicate that short-term exposure at the levels present in the environment or in the home do not cause any apparent detrimental effects. Despite extensive research, to date there is no evidence to conclude that exposure to low level electromagnetic fields is harmful to human health.

11. And: In the area of biological effects and medical applications of non-ionizing radiation approximately 25,000 articles have been published over the past 30 years. Based on a recent in-depth review of the scientific literature, the WHO concluded that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields.

12. Simply put, Dr. Carpenter's method for reaching his opinions is a *black box*. There is no way to judge accuracy, validity or reproducibility of his opinions and it is impossible to know whether other experts would reach similar opinions without knowing the evidence Dr. Carpenter reviewed and considered and how he weighed this evidence in reaching his opinions.

13. Moreover, there is no indication Dr. Carpenter reviewed the biomedical literature relevant to the question at hand nor that he sought out publications and/or reports with conclusions contrary to his opinion(s).

14. There is no indication Dr. Carpenter reviewed plaintiff's medical records. Moreover, as discussed in my item 1, Dr. Carpenter is unqualified to comment accurately on plaintiff's medical condition and especially on plaintiff's prognosis.

15. Much of Dr. Carpenter's testimony focuses on whether exposure to radiofrequency electromagnetic fields cause cancer. This is not at issue in this litigation. Plaintiff makes no claim his cancer was caused by exposure to radiofrequency electromagnetic fields emitted by a smart meter.

16. Moreover, as Dr. Carpenter states: *There is not strong evidence that Waldenström macroglobulinemia is caused by exposure to RF-EMFs*…

17. Further, there are convincing data plaintiff has a hereditary form of Waldenström macroglobulinemia and plaintiff is participating in a study of this cancer at the US National Institutes of Health (NIH). His participation in the study indicates expert physicians at the NIH and plaintiff agree he has a hereditary form of Waldenström macroglobulinemia. There are no data in the biomedical literature of any association between hereditary Waldenström macroglobulinemia and radiofrequency electromagnetic fields including those emitted from a smart meter.

18. To support his opinion exposure to radiofrequency electromagnetic fields from a smart meter *would increase the risk his cancer could worsen* Dr. Carpenter cites 2 studies: (1) Foliart DE, Pollock BH, Mezei G, Iriye R, Silva JM, Ebi KL, Kheifets L, Link M, and Kavet R (2006) Magnetic field exposure and long-term survival among children with

leukaemia. Br J Cancer 94; 161-164; and (2) Svendsen AL, Weihkoph T, Kaaatsch P, Schuz J (2007) Exposure to magnetic fields and survival after diagnosis of childhood leukemia: A German cohort study. Cancer Epidemiol Biomark Prev 16: 1167-1171.

19. For example, both studies are in children with acute lymphoblastic leukaemia, not Waldenström macroglobulinemia. These are entirely different diseases. Acute lymphoblastic leukaemia is a type of leukaemia whereas Waldenström macroglobulinemia is a type of lymphoma. These cancers have different codes in the International Classification of Diseases (ICD). Acute lymphoblastic leukaemia in the study cited occurs in children whereas Waldenström macroglobulinemia occurs in adults. Therapy of these cancers is entirely different as is their prognoses.

20. The study by Foliart *et al*. is flawed for several reasons. First, it was funded by Electric Power Research Institute (EPRI) and Electricite' de France. Both organizations have potential vested interests in the study outcome.

21. Second, there is no indication in the article of potential conflict(s) of interest of the authours. This is considered mandatory in scientific articles.

22. Third, there is no indication that the data are available to other scientists to test reproducibility of the authours' conclusions. This is considered mandatory in scientific articles.

23. Fourth, interviews for exposure and data collection where done by the Public Health Institute whose source(s) of funding are not disclosed.

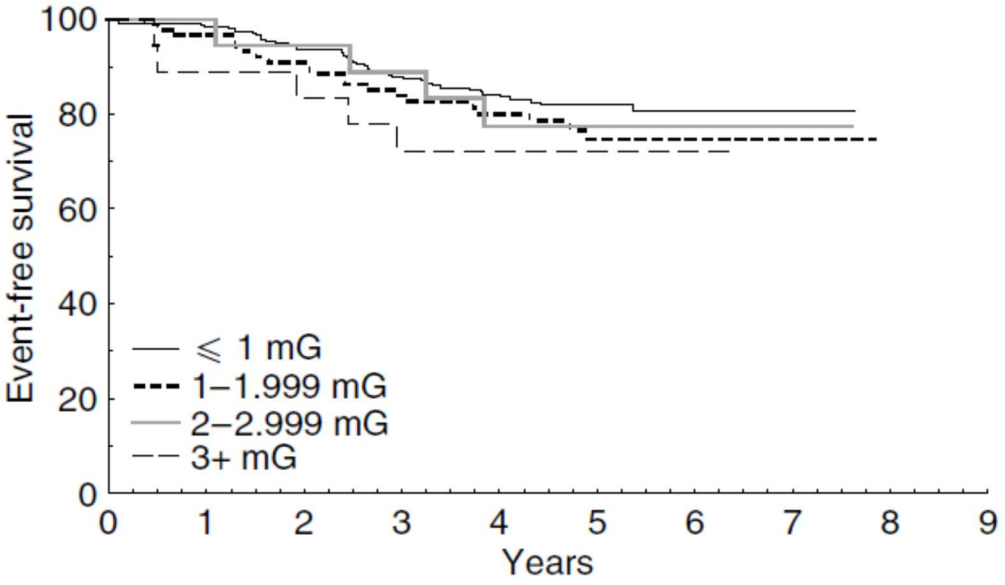
24. Fifth, there are substantial and important subject selection biases. For example, only 29 percent of potential study subjects agreed to participate, 5 percent never returned the meter designed to quantity magnetic field exposure and data from only 79 percent of potential subjects were analyzed. These selection biases make the study conclusions unreliable.

25. These limitations are mentioned by the authours in the article Discussion. They state: *Three limitations of our study are noteworthy. … only 5% of the cohort (19 children)*

had a TWA (time weighted average) *above 0.3 mT*. *Thus, we had limited ability to evaluate outcome among children exposed to more than 0.3 mT and could perform no meaningful analyses above 0.4 mT. Secondly, less than one-third of potentially eligible children enrolled into our study…. Finally, our survival analyses were based on first-year MF exposure assessments. However, a single measurement was less useful among children who changed residences. Twelve percent of children with first-year measurements moved during the exposure assessment protocol. The total number of children who changed residences during the entire course of follow-up is unknown. The single assessment of MF exposure in residentially mobile children may not be an adequate surrogate of MF exposure over the study's extended follow-up period*.

26. Importantly, Dr. Carpenter mis-represents the study conclusion. The study authours state: ***No consistent or statistically significant trend was noted between increasing exposure to MF*** (magnet field) ***and event-free survival or risk of death****. Although we report poorer survival among children with the highest MF exposure category,* ***clinical inferences are limited, with results possibly attributable to chance alone****. Independent confirmation is needed, as our study is the first to look at relapse and survival and thus* ***our findings can be viewed only as hypothesis generating***. (Bolding mine.)

27. The figure below from the article by Foliart *et al*. shows no significant difference in event-free survival of children with acute lymphoblastic leukaemia exposed to different strengths of magnetic fields.



28. The conclusion is this study of the potential impact of magnetic fields on event-free survival and survival of children with acute lymphoblastic leukaemia does not support Dr. Carpenter' opinion …*if a smart meter were placed on Mr. Friedman's house, the elevated exposure coming from it would increase the risk his cancer could worsen …* on several counts including different diseases and his mis- understanding and/or representation of the authours' conclusions.

29. The second article Dr. Carpenter relies on in forming is opinion *if a smart meter were placed on Mr. Friedman's house, the elevated exposure coming from it would increase the risk his cancer could worsen …* is by Svendsen *et al*. These authours also studied children with acute lymphoblastic leukaemia rather than adults with Waldenström macroglobulinemia. The endpoint Svendsen *et al*. studied was survival not event-free survival, the endpoint in the study by Foliart *et al.* Also, Svendsen *et al*. measured 24 hour magnetic field exposure in contrast to Foliart *et al.* who studied a time weighted average. The follow-up interval of the studies also differed: 5 years *versus* almost 10 years.

30. When Svendsen *et al* tried to replicate the event-free survival reported by Foliart *et al*. they reported Hazard Ratios which were not statistically significant. These data indicate conclusions of the Foliart *et al.* study are not supported by results of the study of

Svendsen *et al*. Dr. Carpenter offers no explanation nor does he attempt to reconcile these discordant results.

31. Table 3 of the study by Svendsen *et al*. indicates a non-significant increase in deaths in children in the highest magnetic field exposure cohort. Moreover, the Foliart *et al*. reported worse event-free survival only in children exposed to magnetic fields greater than 0.3 μT which was not found in the study by Svendsen *et al*. These discordances are not discussed by Dr. Carpenter.

32. The article by Svendsen *et al*. does not indicate funding source, potential conflicts of interest nor data availability. These elements are considered essential requirements in scientific articles.

33. Authours of the study by Svendsen *et al*. conclude: *In all, the evidence is still based on small numbers, and a biological mechanism to explain the findings is not known*.

34. There have been several larger studies of event-free survival and survival in children with acute lymphoblastic leukaemia after the publications by Foliart *et al*. and Svendsen *et al*. These studies are much larger and of higher quality.

35. For example, Schuz *et al*. (2012) studied the relationship between exposure to extremely low frequency magnetic fields (ELF-MF) in more than 3,000 children from 6 countries (Schüz J, Grell K, Kinsey S, et al. 2012. Extremely low-frequency magnetic fields and survival from childhood acute lymphoblastic leukemia: an international follow-up study. Blood Cancer J. 2012; 2:e98). These authours reported no impact on event-free survival or survival in children exposed to extremely low frequency magnetic fields in the ranges studied by Foliart *et al*. and Svendsen *et al*. The authours concluded: *ELF–MF exposure has no impact on the survival probability or risk of relapse in children with ALL*.

36. Replicability and reproducibility are required to reach an accurate and precise scientific conclusion. Results of the studies by Foliart *et al*. and Svendsen *et al*. fail to meet this requirement and cannot be relied on in forming a supportable opinion.

37. Consequently, Dr. Carpenter's opinion: … *there is **clear evidence** that elevated exposure to electromagnetic fields shortens survival of children diagnosed with leukemia* ... is not supported by a careful and critical review of the biomedical literature. (Bolding mine.)

38. In forming an opinion it is important to consider and weigh all relevant evidence. There is no indication Dr. Carpenter has done so in reaching his opinion. For example, there are substantial data in animals with cancer on the relationship between exposure to magnetic fields and survival. The most relevant to plaintiff's cancer is a study of lymphoma development in mice exposed to high dose magnetic fields. (Waldenström macroglobulinemia is more closely related to lymphomas compared with acute lymphoblastic leukaemia.)

39. For example, a study by Sommer and Lerchi (2006) reported no increased risk of lymphoma development in mice exposed to very high dose magnetic fields (Sommer, A. M., Lerchl, A. 2006. 50 Hz Magnetic Fields of 1 mT Do Not Promote Lymphoma Development in AKR/J Mice. *Radiation Research*, *165*:343–9).

40. Additionally, Dr. Carpenter implies there is a medical condition he terms *electro-hypersensitivity (EHS)* otherwise referred to as electro-magnetic hypersensitivity and idiopathic environmental intolerance to electromagnetic fields. Notably, he does not opine nor present evidence plaintiff has this or any related condition.

41. The weight-of-evidence indicates there is no such condition in humans. For example, Rubin *et al*. (2010) reviewed data from 46 blinded or double-blinded provocation studies in 1175 persons claiming to have idiopathic environmental intolerance to electro-magnetic fields (Rubin GJ, Nieto-Hernandez R, Wessely S. 2010. Idiopathic environmental intolerance attributed to electromagnetic fields (formerly 'electromagnetic hypersensitivity'): An updated systematic review of provocation studies. Bioelectromagnetics. 31:1-11).

42. The authours reported: *No robust evidence could be found to support this theory.* And: *Despite the conviction of IEI-EMF* (idiopathic environmental intolerance to electromagnetic fields) *sufferers that their symptoms are triggered by exposure to electromagnetic fields,* ***repeated experiments have been unable to replicate this phenomenon under controlled conditions***. (Bolding mine.)

43. Another systematic review consider types of symptoms reported by persons claiming to have idiopathic environmental intolerance to electromagnetic fields (Rubin GJ, Hillert L, Nieto-Hernandez R, *et al*. Do people with idiopathic environmental intolerance attributed to electromagnetic fields display physiological effects when exposed to electromagnetic fields? 2011. A systematic review of provocation studies. Bioelectromagnetics. 32:593-609).

44. The authours identified 29 single- or double-blind experiments in which participants claiming to have idiopathic environmental intolerance to electromagnetic fields were exposed to different EMF (electro-magnetic field) levels and in which objectively measured outcomes were assessed. Only 5 studies identified significant effects of exposure including reduced heart rate and blood pressure, altered pupillary light reflex, reduced visual attention and perception, improved spatial memory, movement away from an EMF source during sleep and altered EEG during sleep. These effects were not confirmed in the other 24 studies.

45. Importantly, none of the effects noted in item 38 are those cited by Dr. Carpenter as potentially affecting plaintiff (fatigue, headache, brain fog, tinnitus).

46. A report from the WHO concluded: *Despite extensive research, to date there is no evidence to conclude that exposure to low level electromagnetic fields is harmful to human health.*

47. Moreover, as indicated, Dr. Carpenter makes no claim plaintiff suffers from what he terms *electro-hypersensitivity*. Instead Dr. Carpenter opines plaintiff's exposure to radiofrequency electromagnet fields emitted from a smart meter *would increase the risk*

his cancer could worsen which in turn logically may exacerbate his symptoms affecting his quality of life and likely shortening it.

48. Consequently, Dr. Carpenter does not opine plaintiff has what he terms *electro-hypersensitivity* but rather plaintiff's exposure to radiofrequency electromagnet fields emitted from a smart meter would worsen his Waldenström macroglobulinemia which, as a result, may exacerbate his symptoms affecting his quality of life and likely shortening it.

49. As I discuss above there are no convincing data including, but not limited to acute lymphocytic leukaemia in children, exposure to radiofrequency electromagnet fields impacts the event-free survival or survival of persons with any cancer including, but not limited to Waldenström macroglobulinemia.

50. It is unclear how Dr. Carpenter can opine to *a reasonable degree of medical certainty* absent appropriate medical training.

51. It is my understanding an opinion should be stated as being *more likely than not*. Nowhere in his testimony does Dr. Carpenter opine to a *more likely than not* standard.

52. In fact, in his testimony he opines plaintiff's potential exposure to radiofrequency electromagnetic fields emitted from a smart meter ***may*** *exacerbate his symptoms.* (Bolding mine.) Anything may happen but this falls short of an event which is *more likely than not*.

53. As such, Dr. Carpenter offers no opinion of the probability, if any, plaintiff would suffer an adverse event such as progression of his cancer or worsening of signs and symptoms as a consequence thereof (the only mechanism he posits).

54. In summary, I opine Dr. Carpenter's testimony and opinions contained therein are unreliable, indicate no unbiased critical review and evaluation of the relevant biomedical literature or disclose any methodology recommended by scientific bodies and regulatory agencies which could allow other experts to replicate his processes.

55. Furthermore, I opine Dr. Carpenter is not medically qualified to opine in this litigation to *a reasonable degree of medical certainty.*

Rebuttal to Testimony of Mr. Kent Chamberlin

1. There are several important errors and limitations which compromise the testimony of Mr. Chamberlin which I detail below.

2. Mr. Chamberlin has no medical training and lacks a scientific basis to opine whether exposure to radiofrequency electromagnet fields including those emitted from a smart meter could affect signs, symptom or prognosis of plaintiff's cancer;

3. Mr. Chamberlin does not describe the method he used to reach his opinions. He does not indicate he followed recommendations for judging scientific evidence from any scientific body or regulatory agency such as: (1) Reference Manual on Scientific Evidence; (2) US Environmental Protection Agency; (3) US National Research Council; (4) US National Academy of Science; (5) US National Toxicology Program [NTP]; (7) US Department of Health and Human Services [US DHHS]; (8) International Agency for Research in Cancer (IARC); (9) World Health Organization (WHO) and others;

4. There is no indication Mr. Chamberlin used a *weight-of-evidence* methodology or any other established and reproducible methodology to evaluate risk from exposure to radiofrequency electro-magnetic fields as recommended by these scientific organizations and regulatory agencies and which is considered best practice in evaluating a scientific or medical question. A *weight-of-evidence* methodology approach is built on to the Hill *viewpoints* but adds elements which increase scientific validity;

5. I discuss the *weight-of-evidence* approach to answering scientific questions in detail above. Briefly put, a weight-of-evidence analysis is a structured synthesis of lines of evidence, possibly of varying quality, to determine the degree of support for hypotheses.

6. There a several stages to a weight-of-evidence analysis: (1) Determining the appropriate focus, based on the objectives and preliminary consideration of available data, formulating the question(s) to be assessed and developing a protocol; (2) Establishing lines of evidence including identifying and selecting studies, assessing the quality of the studies and analyzing a set of studies of similar type; (3) Integrating data from available lines of evidence to determine the degree of support for hypotheses or to estimate quantities of interest; and (4) An explicit presentation of the weight-of-evidence in a form that maximally supports a scientific and/or medical conclusion;

7. It follows that to reach an unbiased scientific opinion it is necessary to review publications and data in the scientific and medical literature. Typically this is done by performing searches for scientific and biomedical publications on relevant topics such as effects of smart meters or similar radiofrequency waves on prognosis and signs and symptoms of cancer, especially in persons with cancers like this of plaintiff. Typically this is done using the PUBMED search engine of the US National Library of Medicine and Google Scholar;

8. In forming a scientific or medical opinion it is necessary to consider publications representing a range of opinions including those supporting and contrary to an experts opinion as stated in this report. There is no indication this was done by Mr. Chamberlin who cites only 2 references which support his opinion regarding plaintiff ignoring a large body of scientific and medical publications with conclusions contrary to his;

9. For example, Mr. Chamberlin cites a report from the International Agency for Cancer Research (IARC), a WHO agency dealing with cancer causation which is not at issue in this litigation but fails to cite or consider a recent report from the WHO stating: *To date, no adverse health effects from low level, long-term exposure to radiofrequency or power frequency fields have been confirmed*.

10. And: *Experiments with healthy volunteers indicate that short-term exposure at the levels present in the environment or in the home do not cause any apparent detrimental*

effects. Despite extensive research, to date there is no evidence to conclude that exposure to low level electromagnetic fields is harmful to human health.

11. And: *In the area of biological effects and medical applications of non-ionizing radiation approximately* 25,000 articles have been published over the past 30 years. Based on a rece*nt in-depth review of the scientific literature, the WHO concluded that current evidence does not confirm the existence of any health consequences from exposure to low level electromagnetic fields*.

12. Simply put, Mr. Chamberlin's method for reaching his opinions is a *black box*. There is no way to judge accuracy, validity or reproducibility of his opinions and it is impossible to know whether other experts would reach similar opinions without knowing the evidence Mr. Chamberlin reviewed and considered and how he weighed this evidence in reaching his opinions. Put otherwise, he hold his opinion **because I say so**;

13. There is no indication Mr. Chamberlin reviewed plaintiff's medical records to understand clinical features, signs, symptoms and prognosis of plaintiff's cancer. Without any medical training Mr. Chamberlin is unqualified to opine what exposures including, but not limited to radiofrequency electromagnet fields including those emitted from a smart meter. might or might not affect clinical features, signs, symptoms and prognosis of plaintiff's cancer;

14. In fact, Mr. Chamberlin's statement regarding plaintiff's health: *Mr. Ed Friedman suffers from a form of non-Hodgkin's Lymphoma, called Waldenstrom's macroglobulinemia*. *This is in general not a curable disease although progression can be delayed with treatment*, is identical to testimony of plaintiff medical expert Dr. David Carpenter;

15. Much of Mr. Chamberlin's testimony focuses on whether exposure to radiofrequency electromagnetic fields cause cancer. This is not at issue in this litigation. Plaintiff makes no claim his cancer was caused by exposure to radiofrequency electromagnetic fields emitted by a smart meter;

16. To support his opinion Mr. Chamberlain cites 2 references: Bann, *et al.* Radiofrequency Electromagnetic Fields: evaluation of cancer hazards," on behalf of the WHO International Agency for Research on Cancer Monograph Working Group, https://monographs.iarc.who.int/wp-content/uploads/2018/06/REF_Poster2012.pdf; and (2) M. Wyde M. et al., "Report of Partial findings from the National Toxicology Program Carcinogenesis Studies of Cell Phone Radiofrequency Radiation in Hsd: Sprague Dawley & lt;sup & gt;®</sup> SD rats (Whole Body Exposures)," bioRxiv, p. 55699, Jan. 2018.

17. Mr. Chamberlin's Bann *et al*. reference is to a poster rather and not the complete scientific report (IARC Monograph 102 Non-Ionizing Radiation, Part 2: Radiofrequency Electromagnetic Fields. IAARC. Lyon, France 2011). It is unclear if Mr. Chamberlin read the relevant IARC monograph but he does not indicate he did so in his testimony nor does he include it in his references;

18. Importantly, the poster Mr. Chamberlain cites deals with cancer causation NOT with whether exposure to radiofrequency electromagnetic fields can worsen signs, symptoms or prognosis of someone with cancer;

19. Mr. Chamberlain opines: *Mr. Friedman's cancer **may or may not** have been caused by exposure to radiation*. (Bolding mine). Clearly, Mr. Chamberlin does not opine it is *more likely than not* plaintiff's cancer was caused by exposure to radiofrequency electromagnetic fields including those emitted from a smart meter;

20. Furthermore, cancer causation as a result of exposure to radiofrequency electromagnetic fields including those emitted from a smart meter is not the matter of this litigation;

21. Further, there are convincing data plaintiff has a hereditary form of Waldenström macroglobulinemia and plaintiff is participating in a study of this cancer at the US National Institutes of Health (NIH). His participation in the study indicates expert

physicians at the NIH and plaintiff agree he has a hereditary form of Waldenström macroglobulinemia. There are no data in the biomedical literature of any association between hereditary Waldenström macroglobulinemia and radiofrequency electromagnetic fields including those emitted from a smart meter;

22. To support his opinion *the likelihood of his cancer worsening is increased by having radiating devices, such as a smart meter*, Mr. Chamberlin cites a study from Brazil which he claims shows: *there is a dose-dependent relationship between death rate from cancer and exposure to radiation* (Dode AC, Leão MMC, Tejo FAF *et al.* 2011. Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais state, Brazil. Sci Total Environ. 409:3649-65);

23. First, this is an ecologic epidemiologic study which Mr. Chamberlin is unqualified to critically review or critically and accurately judge validity of the authours' conclusions.

24. Second, the study deals with the incidence of fatal cancers NOT worsening of sign and/or symptoms nor prognosis in someone with cancer which is the subject of this litigation. The authours make no claim exposure to cell phone base stations worsen signs, symptoms or prognosis of someone with cancer;

25. Consequently, it is unclear if Mr. Chamberlain mis-understands conclusions of the study, the subject of this litigation or both;

26. Mr. Chamberlain fails to cite limitations of the study noted by the authours: *The principal limitations of the present study concern the study design and the use of secondary data. By design, the group results could not be extrapolated to each person in the population. Although the data were well standardized and collected from official personnel in the City Health Department, they are subject to misclassification due to lack of information and errors in the entering of data and diagnosis. Finally, neither the life habits nor the genetic factors of the residents could be taken into account;*

27. There are several peer-reviewed publications challenging conclusions of the study Mr. Chamberlin cites. For example, Foster KR, Trottier L. Comments on "Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais state, Brazil" by Dode et al. (op. cit.);

28. Foster and Trottier note: *The authors do not clearly describe how they obtained the results shown in Table 1 (their Table 5), how they avoided double-counting residents in overlapping 1-km radii surrounding different base stations, or even what is "the base station" to which they refer in the caption to their Table 5, nor do the authors provide a rationale why distance to the "first licensed transmitter" within 1 km of a house should be a useful proxy measure for radiofrequency field exposure to an individual, given the presence of many other sources of radiofrequency energy in the environment (including many base stations erected subsequent to the first transmitter within 1 km of a decedent's residence and not considered in their analysis);*

29. Also: *But there is an even larger problem. The time period of their cancer data, 1996–2006, coincided with the time of rapid buildout of the cellular telephone system. Dode et al. included in their analysis "only the deaths of those who were exposed since the first license date of the BS" within 1 km of each decedent's residence. They did not adjust their data for the length of time over which the base station had been present. Consequently, the number of "accumulated deaths" around each station would vary for the trivial reason that the stations were installed at different times. In the likely event that the cellular telephone network was initially built out with a denser grid of base stations in the central vs. outlying districts, then more residents of Centro-Sul would have lived close to a base station for longer times than in outlying districts, with more "accumulated deaths" simply because of longer accumulation times — regardless of any true variation in cancer death rate;*

30. Also*, Dode et al. make claims that are puzzling and, on face value, biologically implausible: (1) residence close to a base station increases risk of death for all forms of cancer whereas exposure to a carcinogen would be expected to increase only specific neoplasms; (2) the effect appears after only brief exposure whereas tumors have*

latencies of many years after initial exposure to a carcinogen; and (3) the "number of deaths by neoplasia" .. falls off dramatically after 1–2 years of exposure;

31. *The second fatal weakness is the presentation of data in terms of "cumulative deaths" (deaths per 1000 residents summed over varying time intervals) rather than death rate (deaths per 1000 residents per year). These buildings were among the first in the city to receive antennas on their roofs, and consequently many residents of the area will have lived for relatively long times near (in many cases directly beneath) the cellular antennas. Other areas in the city …were relatively bereft of base stations even as late as 2006;*

32. Mr. Chamberlain fails to cite the conclusion of the WHO on the topic of cell phone base stations: *Considering the very low exposure levels and research results collected to date, there is no convincing scientific evidence that the weak RF signals from base stations and wireless networks cause adverse health effects*;

33. Also, in the IARC poster Mr. Chamberlin references (see my item 16) the IARC Working Group states regarding environmental exposures to RF-EMF (radiofrequency-electromagnetic fields): *Ecological and case control studies have been carried out to investigate potential associations of brain cancer with RF emissions from transmission antennas. These studies are generally limited by reliance on measures of geographic proximity to the antennas as an exposure surrogate. Substantial exposure misclassification is unavoidable. For the same reason, no conclusions can be drawn from the limited data that were available on risk for leukaemia, lymphoma or number of other cancers;*

34. It appears Mr. Chamberlain relied on the Dode reference, an environmental study, to support his opinion whilst also relying on the poster by Bann *et al*. but ignores the conclusion of the IARC Working Group regarding environmental studies of radiofrequency electromagnetic fields and cancer causation in the same reference which concluded: *no solid data*;

35. Although exposure to radiofrequency electromagnetic fields are judged by IARC as *possibly carcinogen to humans (Group 2B)* this is not the subject of this litigation. Plaintiff makes no claim exposure to radiofrequency electromagnetic fields was a cause of his cancer;

36. Moreover, Mr. Chamberlain fails to cite conclusion from many other scientific bodies and regulatory agencies which have not classified radiofrequency electromagnetic fields as a human carcinogen. For example, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) determined the studies do not allow the conclusion radiofrequency electromagnetic fields are a human carcinogen;

37. The US Food and Drug Administration (FDA) concluded: *Based on the studies that are described in detail in this report, there is insufficient evidence to support a causal association between radiofrequency radiation (RFR) exposure and [tumor formation]*;

38. The National Toxicology Program (NTP) did not include radiofrequency electromagnetic fields in the 15th Report on Carcinogens (December 21, 2021) which lists substances *known to be a human carcinogens* or *reasonably anticipated to be human carcinogens*;

39. The US Federal Communication Commission (FCC) states: *[C]urrently no scientific evidence establishes a causal link between wireless device use and cancer or other illnesses;*

40. There are many other statistical issues with the Dode study which invalidate Mr. Chamberlin's interpretation;

41. The authours make no claim signs, symptoms and/or prognosis of someone with cancer is affected by exposure to radiofrequency electromagnetic fields from cell phone base towers;

42. Mr. Chamberlain's only other reference is to a study by Wyde *et al*. (Wyde M *et al.* 2011. Report of Partial findings from the National Toxicology Program Carcinogenesis Studies of Cell Phone Radiofrequency Radiation in Hsd: Sprague Dawley & lt;sup & gt;®</sup> SD rats (Whole Body Exposures)," *bioRxiv*, p. 55699, Jan. 2018);

43. This is a study in rats. The reference he cites appears bioRxiv, an unrefereed prereprint server, NOT a peer-reviewed journal. The bioRxiv editorial policy states: Articles are not peer-reviewed … *No endorsement of an article's methods, assumptions, conclusions, or scientific quality by Cold Spring Harbor Laboratory is implied by its appearance in bioRxiv* (https://www.biorxiv.org/about-biorxiv);

44. A search of PUBMED of the US National Library of Medicine (NLM) on 1 January 2022 identified only a technical report from the NTP. No peer-reviewed version of the article by Wyde *et al.* Mr. Chamberlain references as supporting his opinion has been published in the biomedical literature;

45. Importantly, as I discuss in my item 38 above, The National Toxicology Program (NTP) which sponsored the Wyde *et al*. study did not include radiofrequency electromagnetic fields in the 15th Report on Carcinogens (December 21, 2021);

46. In forming an opinion it is important to consider and weigh all relevant evidence. There is no indication Mr. Chamberlin did so in reaching his opinion. For example, A recent WHO report states: *In the area of biological effects and medical applications of non-ionizing radiation approximately 25,000 articles have been published over the past 30 years.* In his testimony Mr. Chamberlin cites 2 references or 1 ten-thousandth of the published literature;

47. It is my understanding an opinion should be stated as being *more likely than not*. Nowhere in his testimony does Mr. Chamberlin opine to a *more likely than not* standard.

48. Mr. Chamberlin offers no opinion of the exact probability, if any, plaintiff would suffer worsening of signs, symptoms or prognosis of his cancer as a consequence exposure to radiofrequency electromagnetic fields including those emitted from a smart meter.

49. Rather his opinion confounds several types of radiation. He states in his conclusion: … based on what is known about the relationship between cancer and **radiation exposure**… and … **radiating devices** … (Bolding mine.) At issue I this litigation is nor radiation *per se* but specifically radiofrequency electromagnetic fields emitted by a smart meter;

50. In summary, I opine Mr. Chamberlin's testimony and opinions contained therein are unreliable, present no balanced critical review of the relevant biomedical literature or disclose the methodology he used to reach his conclusions thereby preventing other experts to replicate his analyses. Moreover, his opinions are contrary to those of most scientific bodies and regulatory agencies. Put otherwise, the support for his opinion is **because I say so.**

51. Lastly, Mr. Chamberlin does not suggest the adverse events he speculates could result from exposure to radiofrequency electromagnetic radiations such as those emitted from a smart meter are *more likely than not* to occur nor does he proffer his opinions to a *reasonable degree of expert certainty*.

Comments on the Deposition of Dr. David Carpenter

I reviewed the Deposition of Dr. David Carpenter on this matter on 13 January, 2022. Specific comments with page and line references follow:

1. Dr. Carpenter testifies 2 articles he cites (Foliart DE, Pollock BH, Mezei G et al.. 2006. Magnetic field exposure and long-term survival among children with leukaemia. Br J Cancer 94:161-4; and (2) Svendsen AL, Weihkoph T, Kaaatsch P *et al.* 2007. Exposure to magnetic fields and survival after diagnosis of childhood leukemia: A German cohort study. Cancer Epidemiol Biomark Prev 16:1167-71) support his opinion. Above I

discuss in detail several reasons these references are unreliable. Briefly, conclusions of the 2 studies are contradictory and the Svendsen study could not confirm conclusions reported in the Foliart study. Second, these data are in children with acute lymphoblastic leukaemia which is different from plaintiff's cancer. Third, no scientific body, medical authority nor regulatory agency recognizes conclusions of these studies. I know of no cancer-related organization including those specialized in therapy of acute lymphoblastic leukaemia which supports conclusions of these studies nor advises children with acute lymphoblastic leukaemia in remission to avoid exposure to radiofrequency electro-magnetic rations like this emitted by a smart meter (nor of any type (p. 36; 10 and following);

2. Dr. Carpenter testifies he has no idea what exposure plaintiff might receive from a smart meter such as the type proposed to be exposed at plaintiff's residence (p. 63, lines 11-18; 66/14; 98/17; 101/23);

3. Dr. Carpenter testifies he has no idea what exposure to radiofrequency electro-magnetic fields is harmful to humans (Page 58; Line 21; Page 59; Line 17; Page 60; Line 10; Page 64; Line 14; and Page 66; Line 7);

1. Dr. Carpenter discuss an article on pages 81-84 by Belpomme *et al.* (Belpomme D, Hardell L, Belyaev I et al. 2018. Thermal and non-thermal health effects of low intensity non-ionizing radiation: An international perspective. Environ Pollut. 242:643-58; Carpenter Deposition Exhibit 8). First, this is a review article rather than a scientific study. Second, Dr. Carpenter is a co-authour of the article. The claim in this article which Dr. Carpenter cites is that exposure to radiofrequency electro-magnetic fields results in the production of reactive oxygen species. The only citation in the article supporting this claim is to an un-peer-reviewed online website (www.bioiniative.org) which has been highly-criticized for lack of scientific accuracy. Even if the claim exposure to radiofrequency electro-magnetic fields were true production of reactive oxygen species would be relevant only to cancer causation and not to progression in someone with cancer in general nor in someone with lymphoplasmacytic lymphoma/Waldenström macroglobulinemia like plaintiff. Moreover, large well-conducted

clinical trials designed to prevent cancer or improve cancer prognosis by interventions which decrease production of reactive oxygen species have been uniformly negative. (Pages 81-84). Lastly, as I discuss in Item 9 below Dr. Carpenter testifies in this Deposition: biological effects don't always translate into a human disease or a hazard to people (Page 61, Line 10; Page 62, Line 7);

2. Dr. Carpenter testifies his opinion regarding medical consequences of radiofrequency electromagnetic fields such as those emitted by a smart meter is minority opinion (Page 78, Line 5) and testifies radiofrequency electro-magnetic fields are "toxic" but admits it's unproved (Page 90; Line 1);

3. Dr. Carpenter testifies he has a conflict-of-interest (Page 70, Line 20; Page 72, Line 15; Page 73, Line 7);

4. Dr. Carpenter testifies articles he cites have nothing to do with plaintiff (Page 83, Line 22; Page 84, Line 16);

5. Dr. Carpenter testifies he cannot cite any article where someone has been harmed by exposure to radiofrequency electro-magnetic fields from a smart meter (Page 93, Line 20);

6. Dr. Carpenter testifies he has no way of knowing what effect exposure to radiofrequency electro-magnetic fields would have on anyone (Page 140, Line 4);

7. Dr. Carpenter testifies he cannot say to a reasonable degree of medical certainty exposure to radiofrequency electro-magnetic fields would shorten remission of someone with cancer by any interval more than 5 seconds (Page 102, Line 8);

8. Dr. Carpenter testifies he authoured a statement about a proposed limit on exposure to radiofrequency electro-magnetic fields he does not believe (Page 56, Line 19);

9. Dr. Carpenter testifies biological effects don't always translate into a human disease or a hazard to people (Page 61, Line 10; Page 62, Line 7);

10. On pages 110-111 Dr. Carpenter discusses development of Schwannomas and brain cancers in rodents exposed to radiofrequency electro-magnetic fields. These studies are in rodents, not humans. The exposure conditions were set to approximate conditions like those of mobile phone exposures, not exposures from a smart meter. These cancers were detected only in male rats and not in genetically-identical female rats. These experiments dealt with cancer causation, not cancer progression. Schwannomas and gliomas are cancers of neural tissue and are entirely unrelated to plaintiff's cancer. Lastly, there is no convincing evidence of an increased incidence of these cancers in human mobile phone users despite extensive study;

11. Dr. Carpenter testifies the same exposure to radiofrequency electro-magnetic exposures might be harmless to one person, mildly harmful to another and seriously harmful to another. He gives no indication in his Declaration or Deposition which type of persons plaintiff is. First, there are no convincing scientific data a condition he terms electro-magnetic hypersensitivity exists. (My Item 40 above.) Specifically, he does not opine nor present evidence plaintiff has this or any related condition (if such conditions exist which is doubtful). For example, on page 83, line 24 of his Deposition he testifies: *… on which Ed does not have, on electrohypersensitivity, which he* [Plaintiff] *does not have and on the full spectrum of these and the cognitive effects, which also he* [Plaintiff] *does not have.* (Page 83, Line 24 to Page 84, Line 2);

This report is a good faith effort to set forth my opinions and the bases thereof. I reserve the right to supplement this report to include further opinions based on additional information, clarifying data, testimony or comments by other technical experts or additional discovery.

Dated: 22February, 2022; Los Angeles, California

Robert Peter Gale MD, PhD

Robert Peter Gale, MD, PhD, DSc(hc), FACP, FRCP, FRCPI(hon), MRSM

Radiofrequency (RF) Radiation

Radiation is the emission (sending out) of energy from any source. X-rays are an example of radiation, but so is the light that comes from the sun and the heat that is constantly coming off our bodies.

When talking about radiation and cancer, many people think of specific kinds of radiation such as x-rays or the radiation made by nuclear reactors. But there are other types of radiation that act differently.

Radiation exists across a spectrum from very low-energy (low-frequency) radiation to very high-energy (high-frequency) radiation. This is sometimes referred to as the **electromagnetic spectrum**.

The electromagnetic spectrum illustration below shows all of the possible frequencies of electromagnetic energy. It ranges from extremely low frequencies (such as those from power lines) to extremely high frequencies (x-rays and gamma rays), and includes both non-ionizing and ionizing radiation.

Examples of high-energy radiation include x-rays and gamma rays. These rays, as well as some higher energy UV radiation, are forms of **ionizing radiation**, which means they have enough energy to remove an electron from (ionize) an atom. This can damage the DNA (genes) inside of cells, which can sometimes result in cancer.

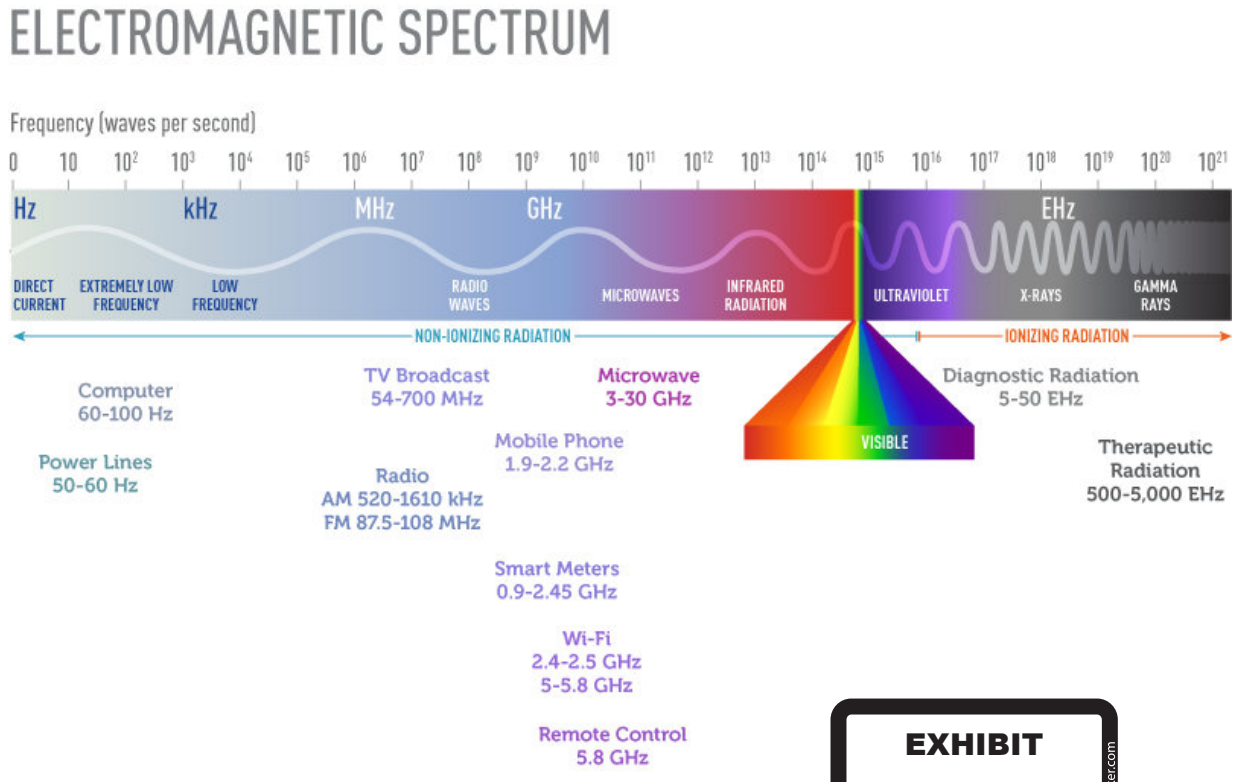


Image credit: National Cancer Institute

EXHIBIT
Exhibit K
exhibitsticker.com

What is radiofrequency (RF) radiation?

Radiofrequency (RF) radiation, which includes radio waves and microwaves, is at the low-energy end of the electromagnetic spectrum. It is a type of **non-ionizing radiation**. Non-ionizing radiation does not have enough energy to remove electrons from an atom. Visible light is another type of non-ionizing radiation. RF radiation has lower energy than some other types of non-ionizing radiation, like visible light and infrared, but it has higher energy than extremely low-frequency (ELF) radiation.

If RF radiation is absorbed by the body in large enough amounts, it can produce heat. This can lead to burns and body tissue damage. Although RF radiation is not thought to cause cancer by damaging the DNA in cells the way ionizing radiation does, there has been concern that in some circumstances, some forms of non-ionizing radiation might still have other effects on cells that might somehow result in cancer.

How are people exposed to RF radiation?

People can be exposed to RF radiation from both natural and man-made sources.

Natural sources include:

- Outer space and the sun
- The sky – including lightning strikes
- The earth itself – most radiation from the earth is infrared, but a tiny fraction is RF

Man-made RF radiation sources include:

- Broadcasting radio and television signals
- Transmitting signals from cordless telephones, cell phones and cell phone towers, satellite phones, and 2-way radios
- Radar
- WiFi, Bluetooth® devices, and smart meters
- The heating of body tissues to destroy them in medical procedures
- “Welding” pieces of polyvinyl chloride (PVC) using certain machines
- Millimeter wave scanners (a type of full body scanner used for security screening)

Some people can have significant RF exposure as part of their jobs. This includes people who maintain antenna towers that broadcast communication signals and people who use or maintain radar equipment.

Most people are exposed to much lower levels of man-made RF radiation every day due to the presence of RF signals all around us. They come from radio and television broadcasts, WiFi and Bluetooth devices, cell phones (and cell phone towers), and other sources.

Some common uses of RF radiation

Microwave ovens

Microwave ovens work by using very high levels of a certain frequency of RF radiation (in the microwave spectrum) to heat foods. When food absorbs microwaves, it causes the water molecules in the food to vibrate, which produces heat. Microwaves do not use x-rays or gamma rays, and they do not make food radioactive.

Microwave ovens are designed so that the microwaves are contained within the oven itself. The oven only makes microwaves when the door is shut and the oven is turned on. When microwave ovens are used according to instructions, there is no evidence that they pose a health risk to people. In the US, federal standards limit the amount of RF radiation that can leak from a microwave oven to a level far below what would harm people. Ovens that are damaged or modified, however, could allow microwaves to leak out, and so could pose a hazard to people nearby by potentially causing burns.

Full-body security scanners

In many airports in the United States, the Transportation Security Administration (TSA) uses full body scanners to screen passengers. The scanners currently used by the TSA use **millimeter wave imaging**. These scanners send out a small amount of millimeter wave radiation (a type of RF radiation) toward the person in the scanner. The RF radiation passes through clothing and bounces off the person's skin, as well as any objects under the clothes. Receivers sense the radiation and create an image of the outline of the person.

Millimeter wave scanners do not use x-rays (or any other kind of high-energy radiation), and the amount of RF radiation used is very low. According to the US Food and Drug Administration (FDA), these scanners have no known health effects. However, TSA often allows people to be screened in a different way if they object to screening with these scanners.

Cell phones and cell phone towers

Cell phones and cell phone towers (base stations) use RF radiation to transmit and receive signals. Some concerns have been raised that these signals might increase the risk of cancer, and research in this area continues. For more information, see Cellular Phones and Cell Phone Towers.

Does RF radiation cause cancer?

Researchers use 2 main types of studies to try to determine if something might cause cancer:

- **Studies done in the lab studies**
- **Studies looking at groups of people**

Often neither type of study provides enough evidence on its own, so researchers usually look at both lab-based and human studies when trying to figure out if something causes cancer.

The following is a brief summary of some of the major studies that have looked at this issue to date. However, this is not a comprehensive review of all studies that have been done.

Studies done in the lab

RF waves don't have enough energy to damage DNA directly. Because of this, it's not clear how RF radiation might be able to cause cancer. Some studies have found possible increased rates of certain types of tumors in lab animals exposed to RF radiation, but overall, the results of these types of studies have not provided clear answers so far.

A few studies have reported evidence of biological effects that could be linked to cancer, but this is still an area of research.

In large studies published in 2018 by the US National Toxicology Program (NTP) and by the Ramazzini Institute in Italy, researchers exposed groups of lab rats (as well as mice, in the case of the NTP study) to RF waves over their entire bodies for many hours a day, starting before birth and continuing for at least most of their natural lives. Both studies found an increased risk of uncommon heart tumors called malignant schwannomas in male rats, but not in female rats (nor in male or female mice, in the NTP study). The NTP study also reported possible increased risks of certain types of tumors in the brain and in the adrenal glands.

While both of these studies had strengths, they also had limitations that make it hard to know how they might apply to humans being exposed to RF radiation. A 2019 review of these two studies by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) determined that the limitations of the studies didn't allow conclusions to be drawn regarding the ability of RF energy to cause cancer.

Still, the results of these studies do not rule out the possibility that RF radiation might somehow be able to impact human health.

Studies in people

Studies of people who may have been exposed to RF radiation at their jobs (such as people who work around or with radar equipment, those who service communication antennae, and radio operators) have found no clear increase in cancer risk.

A number of studies have looked for a possible link between cell phones and cancer. Although some studies have shown a possible link, many others have not. For many reasons, it is hard to study if there might be a link between cell phones and cancer, including the relatively short time that cell phones have been in widespread use, changes in the technology over time, and difficulty in estimating each person's exposure. The topic of cell phones and cancer risk is discussed in detail in Cellular (Cell) Phones.

What do expert agencies say?

The American Cancer Society (ACS) does not have any official position or statement on whether or not radiofrequency radiation from cell phones, cell phones towers, or other sources is a cause of cancer. ACS generally looks to other expert organizations to determine if something causes cancer (that is, if it is a carcinogen), including:

- The **International Agency for Research on Cancer (IARC)**, which is part of the World Health Organization (WHO)
- The **US National Toxicology Program (NTP)**, which is formed from parts of several different government agencies, including the National Institutes of Health (NIH), the Centers for Disease Control and Prevention (CDC), and the Food and Drug Administration (FDA)

Other major organizations might also comment on the ability of certain exposures to cause cancer.

Based on a review of studies published up until 2011, the **International Agency for Research on Cancer (IARC)** has classified RF radiation as "possibly carcinogenic to humans," based on limited evidence of a possible increase in risk for brain tumors among cell phone users, and inadequate evidence for other types of cancer. (For more information on the IARC classification system, see Known and Probable Human Carcinogens.)

More recently, the **US Food and Drug Administration (FDA)** issued a technical report based on results of studies published between 2008 and 2018, as well as national trends in cancer rates. The report concluded: "Based on the studies that are described in detail in this report, there is insufficient evidence to support a causal association between radiofrequency radiation (RFR) exposure and [tumor formation]."

So far, the **National Toxicology Program (NTP)** has not included RF radiation in its *Report on Carcinogens*, which lists exposures that are known to be or reasonably anticipated to be human carcinogens. (For more on this report, see Known and Probable Human Carcinogens.)

According to the **US Federal Communications Commission (FCC)**:

"[C]urrently no scientific evidence establishes a causal link between wireless device use and cancer or other illnesses. Those evaluating the potential risks of using wireless devices agree that more and longer-term studies should explore whether there is a better basis for RF safety standards than is currently used."

How can I avoid exposure to RF radiation?

Because sources of RF radiation are so common in the modern world, there is no way to completely avoid exposure to it. There are some ways you can lower your exposure to RF radiation, such as:

- Avoiding jobs with increased RF exposure
- Limiting the time you spend near appliances, equipment, and other devices (such as WiFi routers) that give off RF radiation
- Limiting the time you spend with a cell (mobile) phone placed against your ear (or close to another part of your body)

Still, it isn't clear that doing these things will be helpful in terms of health risks.

Additional resources

Along with the American Cancer Society, other sources of information include:

Centers for Disease Control and Prevention (CDC)
Toll-free number: 1-800-232-4636 (1-800-CDC-INFO)
Website: www.cdc.gov

Federal Communications Commission (FCC)
Wireless Devices and Health Concerns: www.fcc.gov/consumers/guides/wireless-devices-and-health-concerns
RF Safety FAQ: www.fcc.gov/engineering-technology/electromagnetic-compatibility-division/radio-frequency-safety/faq/rf-safety

National Cancer Institute (NCI)
Toll-free number: 1-800-422-6237 (1-800-4-CANCER)
Website: www.cancer.gov
Electromagnetic Fields and Cancer: www.cancer.gov/about-cancer/causes-prevention/risk/radiation/electromagnetic-fields-fact-sheet

National Institute of Environmental Health Sciences (NIEHS)
Website: www.niehs.nih.gov
Electric and Magnetic Fields: www.niehs.nih.gov/health/topics/agents/emf/index.cfm

**Inclusion on this list does not imply endorsement by the American Cancer Society.*

No matter who you are, we can help. Contact us anytime, day or night, for information and support. Call us at **1-800-227-2345** or visit www.cancer.org.

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